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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 1045

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. March 18, 1922

THE SUNFLOWER AS A SILAGE CROP

By

H. N. VINALL, Agronomist
Office of Forage-Crop Investigations

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EARLY HISTORY OF THE SUNFLOWER.

The common sunflower (*Helianthus annuus*) is generally recognized as native of North America, although its natural range of distribution extends southward to Peru. It was one of the food plants of the American Indians (*14*, p. 419)[1], the seeds being eaten raw or pounded up with other seeds, then made into flat cakes and dried in the sun. The sunflower was grown as early as 1597 in the gardens at Madrid, Spain. The Spaniards probably obtained the seed from Peru, since it was given the name "Peruvian sunflower" by De Lobel, a Flemish botanist, who published a description of the sunflower in 1576. Champlain in 1615 found the Indians in the vicinity of Georgian Bay cultivating the sunflower. The oil which they obtained from the seeds was used on their hair.

[1] The serial numbers (italic) in parentheses refer to "Literature cited" at the end of this bulletin.

The sunflower under cultivation has been widely used as an ornamental, and its seeds are valued as a feed for birds and poultry. In addition, the seeds are used as human food, and when pressed cold produce a fairly good table oil. The resulting seed cake, after the oil has been expressed, is used as a concentrate in feeding cattle and horses. The above-mentioned uses are largely responsible for the widespread distribution of the sunflower.

PRESENT DISTRIBUTION.

The sunflower plant is grown throughout North America, from the southern Provinces of Canada to the Canal Zone. It is to be found also in most parts of South America, but more especially along the west coast from Colombia to Chile. In Australia, New Zealand, South Africa, Egypt, the Mediterranean region of Europe, India, and China the sunflower is grown to a limited extent. It has reached its highest development and its greatest usefulness in Russia, where several important varieties have been developed. It is grown extensively there for its seeds and the oil therefrom, both being consumed as food, and the stalks are utilized as fuel by the peasants.[2] Next to Russia, Hungary was perhaps the largest producer of sunflowers. There were many mills in that country which were equipped especially for extracting the oil from sunflower seeds, and the oil content of the Hungarian seed was higher on the average than that of seed grown in Russia.[3]

CULTIVATION IN THE UNITED STATES.

Although the sunflower is a native of the United States and was cultivated by the Indians, early settlers seem to have made little use of it as a crop plant. Most of the sunflowers grown in early days were harvested for seed, but insects, such as cutworms and also those which live on the seeds, often made the crop an unprofitable one. The United States Department of Agriculture investigated the production of sunflowers in the United States and published the results in 1901 as Bulletin 60 of the Division of Chemistry.

At that time there were no mills producing sunflower oil, and the crop was being utilized largely as feed for cage birds and poultry, the seed only being harvested. In 1895 and 1896 large areas of sunflowers were grown in southern Indiana near Madison. Accord-

[2] Statistics published in the New York Drug Reporter in 1883 claimed a total production of 228,000,000 pounds of seed in Russia from an area of 216,000 acres, mostly in Kielce, Podolia, and the district of Bruitch in Veronez.

[3] A good summary of the information regarding the production of sunflower oil and seed cake in Russia and Hungary is to be found in the articles of Richard Windisch in Landw. Vers. Stat., Bd. 57, p. 305–316, and Dr. Th. Kosutany in the same publication, Bd. 43, p. 253–269.

ing to the United States Department of Agriculture Market Reporter of February 5, 1921, there are now three important seed-producing areas in the United States. These are southeastern Missouri, southern Illinois, and the San Joaquin Valley of California. The 1920 seed crop in these three areas was estimated at 9,850,000 pounds.

The New York Agricultural Experiment Station (Geneva) reported some results with sunflowers in 1883, the Vermont station in 1893, and the Maine station in 1895 and 1896. The Canadian Experimental Farms Report for 1893 also discussed the culture of sunflowers in Ontario and other southern Provinces. The last-mentioned work was devoted mainly to studying the value of the silage mixture originated by Prof. James W. Robertson, of Ottawa, Canada, and designed to produce a silage of such composition that the quantity of grain needed in the ration could be reduced. Corn and some legumes, such as the horse bean or soy bean, were grown together in the field, and when ready for the silo the crop from 2 acres of this mixture was put in the silo with the sunflower heads from half an acre. If it was found desirable to grow the legumes and corn in separate fields; then the mixture was made up by combining the crops as follows: One-fourth acre of sunflower heads, one-half acre of horse beans, soy beans, or some other legume, and 1 acre of corn.

Because of the high protein content of the legume and the high fat content of the sunflower seed, this silage mixture possessed a high feeding value. It was claimed that the Robertson mixture produced results equal to those of pure corn silage and required 4 pounds less of concentrate, such as grain or meal, with each 50 pounds of silage fed.

In growing sunflowers for tests of the Robertson mixture in the New England States and Canada most of the investigators obtained a larger yield of sunflowers (total crop) than they did of corn. Some of them also recognized the possibility of utilizing the entire plant for silage. Prof. J. N. Bartlett, of the Maine Agricultural Experiment Station, says that "the very large total yield of sunflowers (48,000 pounds per acre in 1896) would give them a high rank among coarse fodder plants for silage material." Notwithstanding the heavy tonnage produced by the sunflowers and this apparent realization of the value of such a crop for silage, none of these stations ever seriously attempted to make use of the whole plant by ensiling. The idea seemed to prevail in the minds of all these investigators that there could be very little food value in the coarse woody stalks of the sunflower.

Tests of the feeding value of the Robertson mixture were made with dairy cows at the Vermont station and also in Canada. Although the quantity of grain fed with the Robertson silage was

less than with the corn silage, the cows produced approximately equal quantities of milk and butter. The Canadian authorities reported that the butter made from the sunflower mixture had a richer flavor and higher color than that from corn silage. Instructions were issued to Canadian farmers regarding the growing and utilization of sunflowers in the Robertson silage mixture, and it received considerable attention for a few years. The practice of making silage in this way did not become established in American agriculture, however, and little has been heard about it during the past 10 years.

Outside of the experiments carried out in Maine, Vermont, and New York, there has been but little investigation of the value of sunflowers in the United States until recently, although desultory trials of the crop have been reported by New Hampshire, Nebraska, Colorado, and a few other States. In 1915 the Montana Agricultural Experiment Station grew a small acreage of sunflowers under irrigation at Bozeman. The results were so satisfactory that the plantings were enlarged in 1916, and the crop after being ensiled was fed to dairy cattle. This preliminary test, described in Bulletin 118 of the Montana Agricultural Experiment Station, demonstrated the high feeding value of sunflower silage and resulted in a widespread interest in the crop. Since the publication of this report numerous other States, as well as the United States Department of Agriculture, have experimented with sunflowers rather extensively as a silage crop.

AREAS SUITED TO THE PRODUCTION OF SUNFLOWERS.

Sunflowers are widely distributed in nature and can be grown successfully in nearly every part of the United States. Their value in any region, however, depends more on the measure of success attained in the production of other crops than on their own adaptation to the local climatic conditions. Thus, it is doubtful whether sunflowers will ever be popular for a silage in the central and southern Great Plains, because the sorghums do so well there, nor in the corn belt, because corn so well fills the need for a silage crop. In the Southeastern States corn, sorghum, Japanese cane, pearl millet, and other silage crops are well adapted to the climatic conditions, and sunflowers are not likely to find a place.

In the extreme northern part of the United States or at high altitudes in the Western States where the temperatures during the growing season are relatively low, corn, sorghum, and other crops do not produce heavy yields for silage. In such situations the sunflower is recognized as an extremely valuable silage crop, and the acreage devoted to its production is increasing rapidly. Now that feeding experiments have demonstrated the high quality of this silage, it is probable that the sunflower will be grown quite widely in the New

England States, northern New York, Michigan, Wisconsin, and Minnesota, in North Dakota, Montana, Washington, and Oregon, and also in some of the high valleys of the Rocky Mountain region, such as the San Luis Valley of Colorado.

Sunflowers have been found much more resistant to frost than corn. An observer in Michigan claims that they will "push back the frost line three weeks" in that State. A correspondent in New York writes that his sunflowers were green in the fall two weeks after corn had been killed by frost. These observations explain why sunflowers succeed in the high altitudes of Colorado and other Western States where frosts often occur during the growing season.

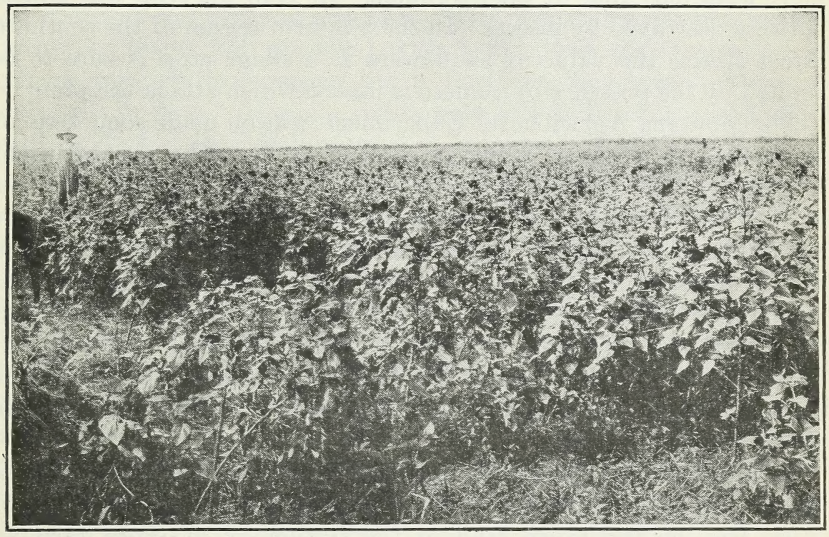

FIG. 1.—A field in Ellis County, Kans., overrun by wild sunflowers during the wet season of 1915.

VALUE OF SUNFLOWERS IN THE SEMIARID REGIONS.

On account of the fact that sunflowers grow wild in western Kansas (fig. 1), Nebraska, South Dakota, and North Dakota, as well as in eastern Montana, Wyoming, and Colorado, it was anticipated that they would be important as a silage crop in dry regions. This has not proved to be the case. The yields at dry-land stations south of the Dakotas have not been large enough to warrant their production under cultivation. Field tests show that the sorghums give much higher yields under such conditions.

At the Fort Hays Experiment Station, Hays, Kans., sunflowers were grown first in 1913. This was an unusually dry year and the plants made a very poor showing. None of them grew over a foot and a half high, and the yield was small. The better varieties of sorghum under the same conditions made a yield of 2 to 2½ tons of

silage per acre. Sunflowers were not grown again at Hays until 1920. The rainfall was fairly abundant that year, and the general crops were good. Sunflowers suffered from rust and insects and again made a very poor showing in comparison with the sorghums.

At Akron, Colo., where the altitude is greater than at Hays, Kans., sunflowers were tested in 1911 and 1912. Only seed yields were obtained in those years, but the growth was good and insects gave little trouble. The estimated total crop was about three-fourths that of the best varieties of forage sorghums.

At Amarillo, Tex., sunflowers were grown in 1911, 1912, and 1913. The first two years the crop was fairly good, but the yield was hardly more than half that of the sorghums. In 1913 the crop was almost entirely destroyed by insects. In the semiarid region of the southern Great Plains the value of sunflowers as a silage crop is sure to be limited by the presence of numerous insects which attack the plant.

The Montana Agricultural Experiment Station made some tests of sunflowers on dry-land farms in 1918 (*4*, p. 9). The average yield of silage on 13 different farms in eight counties was 10.3 tons per acre. There was no basis for a comparison of this yield of sunflowers with that of corn grown under similar conditions. The conclusion at the Montana station, however, was that considering the low seasonal rainfall the yield obtained was quite satisfactory and "that sunflowers are promising dry-land forage producers." This is perhaps true in Montana, where the temperatures are low during the growing season and sorghum and long-season varieties of corn can not be grown.

Sunflowers were grown for ensilage in 1920 at the United States Sheep Experiment Station near Dubois, Idaho,[4] at an elevation of 5,700 feet, on the range land of the station by dry-land farming methods. The land is of lava-rock formation, and the area available for cultivation is limited. Although the annual precipitation is about 16 inches, it was so dry in 1920 that wheat on the farmed lands adjacent to the sheep reserve was a total failure. Regardless of this fact, the sunflowers yielded between 4½ and 5 tons of ensilage per acre.

To obtain a maximum crop of sunflowers by dry-land farming Mr. McWhorter advises the following procedure:

(1) Summer fallow. Plow the land the previous spring. Keep the plowed area free from weeds and covered by a dust mulch throughout the summer and fall.

[4] The work at this station is conducted by the Bureau of Animal Industry of the United States Department of Agriculture. Mr. V. O. McWhorter, who is in immediate charge of the station, has kindly furnished, through Mr. D. A. Spencer, senior animal husbandman in sheep and goat investigations, a preliminary statement of the results obtained with sunflowers. All future statements in this bulletin regarding work at the Dubois station are based on this report.

(2) Plant early. Plant the sunflower seed in a well-stirred yet firm bed as early in the spring as the condition of the ground will permit. Although heavy freezing is injurious to the young plants, light frosts do not hurt sunflowers.

(3) Harrow. When the young plants begin to appear, use a spike-tooth harrow adjusted for shallow cultivation.

(4) Thin the plants in the rows. Make the rows as far apart as corn is usually planted. When the shoots are well started, thin to one or two plants to the hill, 30 to 36 inches apart in the row.

(5) Cultivate thoroughly. Cultivate lightly with an ordinary corn cultivator as often as needed.

SOIL RELATIONS AND EFFECT ON THE FOLLOWING CROP.

No very definite information regarding the behavior of sunflowers on different soil types is available. The best yields are obtained on rich clay loams well supplied with humus, but the crop has been grown successfully on sandy soil in northern Michigan and on poor clay soils in West Virginia. Sunflowers will thrive on any soil which will produce a good crop of corn.

It was observed on the fields of the Washington Agricultural Experiment Station (*17*, p. 11) in 1919 and 1920 that the outside rows of the sunflower plats next to the corn made a more vigorous growth than rows in the centers of the plats. Conversely, the corn rows next the sunflower plats were less vigorous than the rows in the centers of the plats. This seemed to indicate an ability on the part of the sunflowers to obtain a greater portion of the plant food and soil moisture than corn when grown in competition with that crop. The plats which produced corn and sunflowers in 1919 were seeded to wheat in 1920. The average yield of wheat on the corn plats was 33.78 bushels and on the sunflower plats 28.36 bushels per acre. These results at the Washington station indicate that sunflowers are more exhaustive of the plant food and moisture in the soil than corn. This can be accounted for in most part by the larger tonnage obtained from the sunflowers. More experiments of this kind are necessary before definite conclusions are possible.

VARIETIES.

The principal variety of the sunflower now grown in the United States for silage purposes is the Mammoth Russian. This variety usually has a single stalk with comparatively few branches and one head 6 to 12 inches in diameter. The seeds are approximately half an inch long and one-fourth to five-sixteenths of an inch wide. They vary in color from almost pure white to black; most of them, however, are white with longitudinal streaks or bands of gray or black. The Mammoth Russian is a vigorous heavy-stemmed variety with large leaves and produces heavy crops of seed.

Wiley (*19*) says that three principal varieties are grown in Russia: One with large white seeds, valued for its high oil production; one with smaller black seeds, which are sweeter and regarded as best for eating; and the intermediate form with striped seeds, used both for food and for oil production.

The common wild sunflower of the United States often has a much-branched stalk (fig. 2), with numerous heads 3 to 4 inches in diameter. The yield of silage produced by this plant when grown on rich soil under cultivation is usually somewhat less than that obtained from the Mammoth Russian variety under the same conditions. At Red-

FIG. 2.—Two rows on the left, Mammoth Russian sunflowers; two rows on the right, wild sunflowers, Redfield, S. Dak. Both varieties were seeded on April 28, 1920, and photographed in August.

field, S. Dak., in 1920 the total crop, green weight, of the wild sunflower was 13.9 tons per acre, while the Mammoth Russian in an adjoining plat yielded 15.2 tons per acre.

There has been no extensive development of sunflower varieties in the United States. The seed trade has advertised at times six or eight supposedly different varieties, but many of these are only slightly differing strains or selections of the same variety. Probably the most extensive varietal trial made was that of the Department of Agriculture of Ontario, Canada. In 1894 and 1895 seven varieties were under test at Ottawa.[5] These varieties, *Helianthus globosus*,

[5] Ann. Rpt., Dept. of Agr., Ontario, v. I, p. 261. 1895.

Texas Silver Queen, Black Giant, Mammoth Russian Giant, Common, Double California, and Silver and Gold, yielded in the order named 10.63 to 4.87 tons per acre except the last-named variety, which was tested only in 1895 and produced in that year at the rate of 11.39 tons per acre. These same varieties were continued under test in 1896, but a poor stand was obtained, and the year's results therefore were not included in the averages. The seed for these tests ordinarily was purchased from seed houses in the United States.

Notwithstanding the fact that some of these varieties made a very good showing, most of them were discarded and only three, the Black Giant, Mammoth Russian, and White Beauty, were grown in subsequent years. In the report for 1897 this action is explained as follows: "As some of these varieties, however, did not give satisfactory results nearly all of them were dropped from the list." Since a number of the seven varieties, such as the *Helianthus globosus* and Texas Silver Queen, made larger yields than any of the varieties contained in the tests, it is evident that some consideration other than the yield must have been responsible for the action of the Ontario officials in discontinuing the tests of those varieties. The average yield, green weight, of the varieties included in the test for 16 years was Black Giant, 22.3; Mammoth Russian, 17.8; and White Beauty, 16.5 tons per acre.

The Michigan Agricultural Experiment Station conducted a variety test of sunflowers in 1918, but this test developed quite largely into a question of rust resistance.[6] The Mantica, developed by Luther Burbank; the Kaeurpher, from South America; the Mammoth Russian; and the Double Mixed were tested. Of these varieties the Kaeurpher was the only one which proved rust resistant. More experimental work with varieties will have to be conducted before a decision can be reached as to the best variety for silage purposes.

GROWING SUNFLOWERS FOR SILAGE.

Only within the past decade have sunflowers been grown extensively in the United States for silage. In growing the crop for this purpose it is, of course, important to use cultural methods that will yield the largest tonnage. To attain this result it is usually necessary to plant more thickly than where a seed crop is the object.

The same treatment of the soil that prepares the surface for corn planting will answer for sunflowers. The ground is usually plowed in the spring and worked down with a spike-tooth harrow, or if fall

[6] Mich. Agr. Exp. Sta. Quar. Bul., v. 3, no. 3, Feb., 1920, p. 128–129.

plowed it can be put into condition for planting by disking in the early spring.

DATE OF SEEDING.

The best date to plant sunflowers of course varies with the locality. In the Upper Peninsula of Michigan at the Chatham Experiment Station (*15*, p. 50) it was found that seeding May 26 gave a larger yield and a better quality of silage than on June 2 and 9.

At the West Virginia Agricultural Experiment Station, Morgantown, W. Va. (*3*), June 5 proved a satisfactory date for seeding. At the Montana Agricultural Experiment Station at Bozeman (*4*, p. 9), seedings were made each week in 1918 from April 29 to June 10. The largest yields were obtained from seed sown on the earliest date. Seeded on April 29 the plants appeared above ground in 12 days and the yield was 39.7 tons of silage per acre; sown one month later, May 29, the young plants were up in 5 days and the yield was 36.8 tons, green weight, per acre; sown June 10 the plants were up in 3 days and the yield was 22 tons, green weight, per acre. The seedings made between April 29 and May 29 gave lower yields than the May 29 seeding, although they were higher than the yield for June 10. The recommendations of the Montana station, based on the rather inconsistent results obtained in 1918, are to defer seeding in the higher altitudes until the ground is warm and in good condition.

On the Scottsbluff Reclamation Project Experiment Farm, Mitchell, Nebr., good results were obtained from seedings made on May 24 (*8*, p. 25). At the experiment stations at Akron, Colo., Hays, Kans., and Amarillo, Tex., seedings have been made from May 15 to June 15.

These date-of-seeding tests indicate that sunflowers may be sown at the same time the farmer plants corn.

METHOD AND RATE OF SEEDING.

In early experiments with sunflowers in Maine, Vermont, New York, and in Canada the seedings were usually made with a corn planter in rows 3 feet apart. It was advised that not more than three or four seeds be dropped in each foot of row space. In some cases the plats were thinned so that the plants stood 8 to 12 inches apart in the row.

In later experiments carried on in West Virginia, Michigan, Montana, Nebraska, and other western points the ordinary grain drill has been found better suited for seeding sunflowers than the corn planter. The required space between the rows is accomplished by stopping up a certain number of holes or feeds in the drill box. In general, the largest yields and the best quality of silage have been

obtained when the rows were 24 to 30 inches apart. For such seedings 6 to 8 pounds of seed per acre are required.

At the Michigan station (*15*, p. 50) sunflowers were seeded in rows 6, 12, 18, 24, 30, 36, and 42 inches apart. The best yields were obtained from the 30-inch rows. At Huntley, Mont. (*7*, p. 12–14), sunflowers drilled in rows 20 inches apart produced 37.6 tons silage per acre; in rows 30 inches apart, 32.9 tons; and in rows 40 inches apart, 31.0 tons per acre. At Bozeman, Mont. (*4*, p. 6, 7), sunflowers were seeded in rows 8, 20, 24, 30, 36, and 42 inches apart, the quantity of seed varying from 30 to 4 pounds per acre, according to the width of row. The average yield of silage for the two years 1917 and 1918 was highest in the 36-inch rows, 44.1 tons per acre. The 8-inch rows were second, with a yield of 39.8 tons per acre, and the 30-inch rows ranked third, with 33.6 tons of silage per acre.

Other experiments designed to determine the comparative value of planting in hills were carried out at Huntley and Bozeman, Mont. Sunflowers were planted in hills 6 and 12 inches apart in all the different row widths at Huntley and in hills 4, 8, and 12 inches apart in each of the row widths, 24, 30, and 36 inches, at Bozeman. At Huntley the average silage yield of the drilled plats in the three different row widths was 33.8 tons per acre; for the 6-inch hills, 30.6 tons; and for the 12-inch hills, 30.2 tons per acre. At Bozeman (*4*, p. 7, 8), although the highest single yield reported, 44.1 tons per acre, was from drilled rows 36 inches apart and the lowest, 18.2 tons per acre, from hills 42 inches apart each way, the averages showed larger yields for the plats planted in hills than for those drilled. The actual difference in yield, however, was small. The average for the three row widths in drilled seedings was 34.8 tons of silage per acre; for the rows planted in hills 4 inches apart, 36.2 tons; in hills 8 inches apart, 35.3 tons; and in hills 12 inches apart, 35.7 tons per acre.

The results at the two stations are contradictory, and further work will be necessary to clear up the value of these two methods. It is somewhat easier to drill the seed in the row than to plant in hills at the distances obtaining in these experiments. It is evident from the experiments already completed that where the hills are separated by a considerable distance, as they are in checkrowed corn, the yields are appreciably smaller than in drilled rows.

CULTIVATION AND IRRIGATION.

If a crust forms on the soil before the plants come through or immediately afterwards, a light harrowing will help to obtain a good stand. After the plants are 4 to 8 inches tall the ordinary corn cultivator may be used, just as with corn. In some cases, like

that reported by the West Virginia Agricultural Experiment Station, the growth is so rapid that only one cultivation is necessary, after which the plants shade the ground so thoroughly that weeds can not grow. Ordinarily, however, two or three cultivations are necessary.

At the Huntley, Mont., experiment farm three irrigations were given sunflowers seeded May 21, 1918, water being applied uniformly to the field on July 9, August 2, and August 18 (7, p. 12–14). In 1917 five irrigations were given. The frequency and character of cultivations and irrigations will necessarily have to be determined to a large degree by the grower. The large growth produced and the consequent high rate of water loss in dry regions means a correspondingly high water requirement.

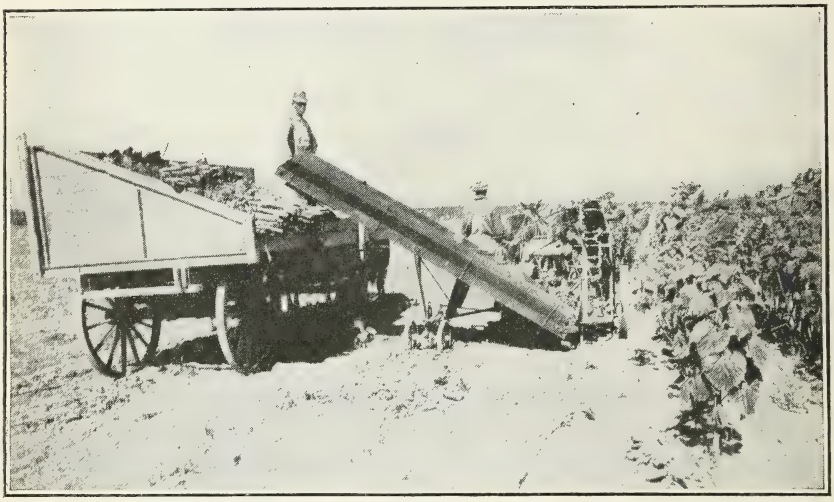

FIG. 3.—Harvesting sunflowers for silage with a row binder equipped with an elevator to carry the bundles directly into a header barge.

HARVESTING METHODS.

The most efficient method of harvesting sunflowers for silage where the crop has not lodged badly and the stalks are not too large in diameter is with the ordinary corn or row binder. This machine ties the stalks in bundles, making it easier to load and transport them to the silage cutter. Everything possible should be done to reduce to a minimum the handwork required. Farm laborers dislike to handle sunflowers on account of the resinous exudation on the stems, especially where they are cut or bruised, and also because of the rough surfaces of the stems and leaves.

At the Dubois (Idaho) sheep station an elevator was devised to carry the bundles directly from the row binder into a header barge. (Fig. 3.) Sunflower plants 8 to 9 feet tall were handled by the

binder with this loader attachment. A machine thus equipped reduces the hand labor to a minimum.

Where the crop has lodged or a row binder is not available, the sunflowers may be harvested with a sled to which knives have been attached or with an ordinary corn knife (fig. 4). Either of these methods of harvesting should be used only in an emergency. Many farmers have reported that it is necessary to pay farm laborers increased wages when such work is in progress.

TIME TO CUT SUNFLOWERS.

There has not been a sufficient number of experiments to determine definitely the best stage of maturity at which to cut sunflowers for silage. The Montana Agricultural Experiment Station (*4*, p. 20–21) conducted feeding experiments with two lots of silage; one from

FIG. 4.—Cutting sunflowers for silage by hand. This method should be used only when the crop has been tangled by the wind or is too heavy for a row binder to handle.

sunflowers cut early, when only 30 per cent of the plants were in bloom, and the other lot from sunflowers cut later, when 90 per cent of the plants were blooming. Unfortunately, no figures showing the comparative yields of silage for the two methods are given, and the results of the feeding test are not conclusive. The dairy cows fed on the early-cut silage produced slightly less milk and butter fat, but gained more in weight than those fed on the late-cut silage. However, the cows fed the early-cut silage consumed a little more silage and grain than those fed late-cut silage. The evidence, therefore, points to a slight advantage in the late cutting. The investigators conclude that sunflowers should not be cut for silage until 50 to 60 per cent of the plants are in bloom, not only because of the

apparent higher feeding value of the late-cut silage, but because there is also a greater loss of juices when the plants are harvested at an earlier stage.

There has been trouble in several cases caused by the loss of juice from sunflower silage. At the field station of the United States Department of Agriculture, at Ardmore, S. Dak., 57 tons of sunflowers were cut about August 25, 1920, and stored in a wooden silo 12 feet in diameter. The silo was filled to a depth of 24 feet. During the first month it was estimated that several thousand gallons of juice escaped through the cracks and around the doors. This loss of juice was accompanied by a shrinkage of 40 per cent in bulk. Other reports of the loss of juice from sunflower silage have been received. In several of these instances, however, the sunflowers were cut when one-third or less of the plants were in bloom. Such sunflowers might be expected to produce "sappy" silage.

At the Huntley, Mont., experiment farm in 1918 the sunflowers were harvested for silage when "on about one-half the plants seed heads were formed, and some were so far advanced that the seeds were in the hard dough stage. The remainder of the plants were in various stages of blooming." The silage made from this crop was not very readily eaten by the cows. This was seemingly due to the fact that much of the silage remained hard and woody in the silo. The report states that apparently the sunflowers were allowed to become too mature before harvesting to make the most palatable silage.

At the West Virginia station (*3*, p. 2, 6, and 7) the sunflowers were cut for silage "when the majority of the seeds of the plants were in the light dough stage." No difficulty was experienced either in harvesting or ensiling the sunflowers at this stage of maturity, and none of the silage was refused or not eaten by any cow during the entire test. "After a few days the cows ate the sunflower silage practically as well as corn silage."

The composition of sunflower plants at different stages of maturity is shown by a series of analyses made at the West Virginia Agricultural Experiment Station in 1919 (*3*, p. 3). Additional work of this nature has also been done by Shaw and Wright (*18*) of the United States Department of Agriculture. They found that sunflower plants 3 feet high contained 84.87 per cent of moisture; 6 feet high, 86.02 per cent; in first flower, 84.09 per cent; with rays ready to fall, 83.9 per cent; with rays dry and partly fallen, 75.58 per cent; with rays all fallen, 74.37 per cent; and when the seeds were hard and mature, 69.68 per cent. This decrease in the percentage of moisture as the plant grows older conforms more nearly with the conditions existing in other plants than do the continuously high moisture percentages found at the West Virginia station. The sun-

flowers used in the experiments of Shaw and Wright were grown at Beltsville, Md. Corn grown in the same field had 68.69 per cent of moisture at the time it was sufficiently mature to put in the silo.

The average amount of moisture in sunflower silage, as shown in Table 2 of this bulletin, is 77.8 per cent. This is less than that of silage made from immature corn and only 6.9 per cent greater than the percentage of moisture in silage made from mature corn.

The results of Shaw and Wright also indicate that the percentage of proteids in the plant steadily declines as it matures. The sugar content also decreases. The greatest difference, however, is in the starch content. In corn at the time it is ready for the silo 24 per cent of the dry matter of the plant is starch; in the sunflower less than 1 per cent is starch. The starch and sugars combined constitute 37 per cent of the total dry matter of the corn plant and only 11.2 per cent of the sunflower plant.

Shaw and Wright conclude from their chemical data that the best time to cut sunflowers for silage is when the ray flowers have become

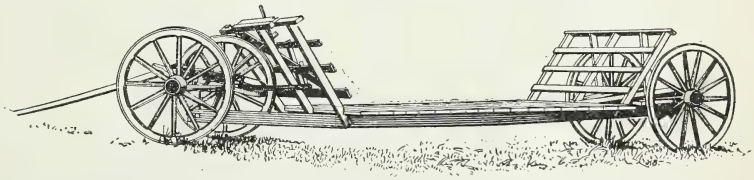

FIG. 5.—Low flat-topped wagons save much hand labor in loading sunflowers to be hauled to a silo.

dry and are partly fallen. Judging from the limited information now available regarding the use of sunflowers for silage, it is best to cut the crop before the seeds have reached the hard dough stage. Most writers advise harvesting sunflowers for silage when only 50 to 60 per cent of the plants are in bloom. Decision regarding the best stage of maturity at which to cut will depend somewhat on location, especially as to rainfall and atmospheric humidity. In dry climates the plants can be harvested at an earlier stage of maturity than in humid climates.

FILLING THE SILO.

For hauling the sunflowers to the silo low flat-topped wagons, such as are used for hauling corn silage, are desirable (fig. 5). The ordinary silage cutter can be used for sunflowers, but one with a wide throat is desirable in order to accommodate the large heads. The knives should be adjusted to a quarter-inch cut and bolted on the cutter securely, because the stalks of the sunflower are somewhat hard and woody.

Little trouble will be experienced in cutting sunflowers if the plants are fed into the silage cutter tops first. Sunflower silage packs more easily than corn silage. If harvesting has been delayed for any reason until the sunflowers are older and somewhat dry it will be necessary to add water along with the silage. With such silage more care is required to tramp it down thoroughly. Sunflowers usually produce an inferior quality of silage if harvested later than the blooming stage.

A word of caution is necessary in regard to the strength of the silo used in storing sunflower silage. Those who have had experience in ensiling sunflowers find that they pack much more closely

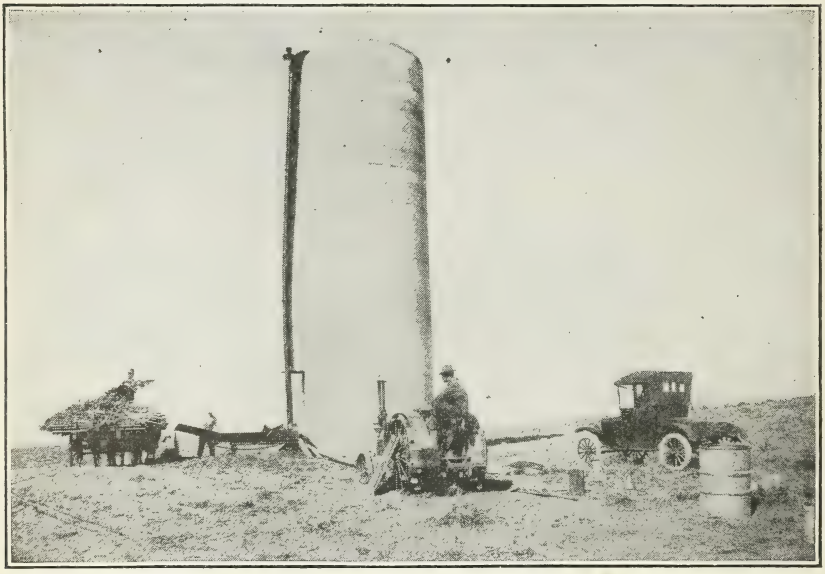

FIG. 6.—Filling with sunflowers the 200-ton concrete silo on the United States Sheep Experiment Station near Dubois, Idaho.

in the silo than corn. This close packing, of course, means heavier silage and in large silos results in much greater pressure on the walls of the silo. George M. Rommel, formerly Chief of the Animal Husbandry Division, Bureau of Animal Industry, United States Department of Agriculture, is authority for the statement that a silo constructed to hold 200 tons of corn silage will hold nearly 300 tons of sunflower silage.

Rommel says that a new monolithic concrete silo 14 feet in diameter and 50 feet high was built with 6-inch walls and the ordinary quantity of metal reinforcement on the United States Sheep Experiment Station near Dubois, Idaho, in 1920. (Fig. 6.) This silo, while it was being filled with sunflowers that fall, began to crack from the pressure when it was little more than half full. Fill-

ing had to be discontinued and the silo reinforced with steel bands in order to save it. Rommel found on inquiry that many farmers in the Northwest who had filled their silos with sunflowers had had similar experiences.

One of the hoops on a wooden silo at Huntley, Mont., burst while the silo was being filled with sunflowers, making it necessary to reinforce the silo with an iron band. Inquiries addressed to the Montana, Washington, and Oregon agricultural experiment stations, however, elicited the information that no trouble of this kind had been encountered at those stations, and none had been reported to them by farmers.

Nothing definite is yet known about the comparative pressure exerted on the silo walls by corn and sunflower silage. No advice can be given, therefore, as to the additional reinforcement necessary for silos intended to hold sunflowers. Care should be used, however, in building such a silo, and the ordinary silo should be watched closely while it is being filled with sunflowers and until the settling process is completed. If it shows signs of cracking, serious trouble can be averted by reinforcing it with iron bands.

YIELDS OF SILAGE.

The yields of sunflower silage have been consistently larger than those of corn or other silage crops in the northern part of the United States and the higher altitudes of the Rocky Mountain region, where the temperatures are low during the summer season. The results of the more important of these comparative tests are listed in Table 1.

Where the yields are recorded for different rates of seeding, as at Huntley, Mont., that given in the table was obtained from drilled rows 30 to 36 inches apart, because drilling in rows is the more common method of culture and the one which no doubt will be most widely used by farmers. This method has not always given the largest yield, as will be seen by reference to the paragraph on the rate and method of seeding. The average yields of sunflowers, corn, and sorgo are not given, because these three crops were not all grown at a sufficient number of the stations to make the averages comparable. In the first series of yields from Guelph, Ontario, the Mammoth Russian variety of sunflowers, which made the second highest yield among the sunflower varieties tested, is compared with the second highest yielding varieties of corn and sorgo. In the second series the Black Giant variety of sunflower is compared with Wisconsin No. 7 corn and Orange sorgo. These varieties made the highest silage yields, respectively, of each of the crops under test.

TABLE 1.—*Comparison of the yields per acre of sunflower, corn, and sorgo silage.*

[Yields obtained under irrigation are given in italic figures; those not in italic were obtained without irrigation.]

Locality.	Year.	Yields per acre (tons).		
		Sunflowers.	Corn.	Sorgo (cane).
Pullman, Wash	1919 and 1920	[a]11.6	[a]6.0	.....
Umatilla, Oreg	1918	*28.4*	*10.8*	.....
Moro, Oreg	1917	1.6	.....	.....
Wallowa County, Oreg	1920	*22.5*	.....	.....
Do	1920	7.0	.....	.....
Reno, Nev	1917	*23.1*	*14.2*	.....
Do	1918	*19.9*	*13.0*	.....
Moscow, Idaho	1919	13.0	10.0	.....
Bozeman, Mont	1915	*36.8*	.....	.....
Do	1916	*31.1*	.....	.....
Do	1917 and 1918	[a]*33.6*	.....	.....
Havre, Mont	1920	3.3	2.6	.....
Huntley, Mont	1917	*19.4*	*10.5*	.....
Do	1918	*32.9*	*9.3*	.....
Do	1919	*27.8*	*10.4*	.....
Laramie, Wyo	1919	*12.0*	.....	.....
State College, N. Mex	1919	*20.0*	*15.0*	*20.0*
Tucumcari, N. Mex	1920	4.3	3.9	.....
Dickinson, N. Dak	1918	10.5	6.1	.....
Do	1919	3.0	2.0	.....
Do	1920	8.3	4.0	.....
Newell, S. Dak	1917	*12.6*	[b]*10.4*	.....
Do	1918	*12.8*	*8.2*	[c]*11.3*
Redfield, S. Dak	1920	15.2	10.4	15.5
Scottsbluff, Nebr	1917 to 1919	[a]*16.3*	[a]*14.6*	.....
St. Paul, Minn	1919	10.0	10.0	.....
Duluth, Minn	1918	18.3	.....	15.6
Chatham, Mich	1919	25.0	.....	.....
Clinton County, Ill	1919	15.5	11.0	.....
Morgantown, W. Va	1919	18.0	8.5	.....
Cazenovia, N. Y	1919	18.0	7.5	.....
Orono, Me	1895	24.4	.....	.....
Guelph, Ontario, Canada	[d]	17.1	15.8	16.7
Do	[e]	20.3	16.9	17.2
Calgary, Alberta, Canada	1919	*39.0*	*14.0*	.....

[a] The yield given is the average for the years specified.

[b] The corn yields listed are those of the Payne White Dent, the highest yielding variety which matured sufficiently to make good silage. Red Cob corn, a southern variety, made an average yield of 13.15 tons per acre for the two years, but was so immature when harvested that the silage was of very poor quality.

[c] The Red Amber sorgo was too immature when harvested to make good silage.

[d] Average yields of Mammoth Russian sunflower and White Cap Yellow Dent corn each for 13 years and Minnesota Amber sorgo 15 years.

[e] Average yields of Black Giant sunflower and Wisconsin No. 7 corn each for 13 years and Orange sorgo 15 years.

There are other tests of these crops mentioned in agricultural literature, but no definite yields are given. In the Quarterly Bulletin of the Michigan Agricultural College for May, 1920, it states that in 1919 careful estimates of the yields on eight farms in Ogemaw, Grand Traverse, Otsego, and Emmet Counties showed that "on an average sunflowers yielded 20 per cent greater tonnage per acre than the corn grown in the same fields. On the college farm at East Lansing, a 3-acre strip of sunflowers produced a 30 per cent greater tonnage than an equal area of corn adjacent." C. B. Tillson, county agricultural agent of Clinton County, N. Y., writing in the Rural New Yorker, February 21, 1920, says that there were 30 tests of sunflowers in Clinton County in 1919 and that in many instances the sunflowers outyielded corn from 30 to 35 per cent. He adds that the sunflowers out-

yielded the corn most where the conditions were least favorable for the corn. He believes that sunflowers will be grown most extensively on farms unsuited to the production of silage corn.

The yields shown in Table 1 seem very favorable to sunflowers because the tests were made mainly in those regions where the large-growing varieties of corn suited for silage purposes are not adapted to the climatic conditions. It can be said also that a large part of these yields was obtained under irrigation. (Fig. 7.) Where the crops can not be irrigated and in localities where silage varieties of

FIG. 7.—Sunflowers grown for silage purposes under irrigation on the Scottsbluff Reclamation project, near Mitchell, Nebr., 1917. Yield, 22.9 tons per acre, green weight.

corn mature properly, the comparative yields of corn and sunflowers are much less favorable to the latter.

FEEDING VALUE OF SUNFLOWER SILAGE.[7]

Considering the fact that only a few years have elapsed since an interest in the use of sunflowers for silage was created by the experiments at the Montana Agricultural Experiment Station in 1915, a comparatively large number of feeding experiments have been carried out. Most of these indicate that sunflower silage when properly made is equal to corn silage for milk-production purposes. Sunflower silage has also been fed at the Montana station to beef cattle, breeding ewes, and brood sows with good results.

[7] Prepared with the advice and cooperation of the Animal Husbandry Division of the Bureau of Animal Industry, United States Department of Agriculture.

COMPOSITION AND DIGESTIBILITY.

The composition of sunflower silage, as shown by chemical analyses, compares very favorably with that of corn and the sorghums. While somewhat lower in carbohydrates or nitrogen-free extract than the corn and sorghums, it is, on the other hand, higher in fat and protein. The analyses made at different places are presented in Table 2.

TABLE 2.—*Comparison of the composition of sunflower, corn, and sorghum silage.*

Kind of silage.	Number of samples.	Constituents (per cent).						Authority.
		Water.	Ash.	Crude protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	
Sunflower	4	78.6	1.6	2.1	6.8	10.4	0.5	Mont. Bul. 131, p. 14.[a]
Do	3	78.5	2.4	2.4	5.8	9.8	1.1	Jour. Agr. Res., v. 18, p. 327.
Do	1	67.8	3.4	4.3	6.6	16.6	1.3	M. J. Blish, for silage from Ardmore, S. Dak.
Do	1	76.2	2.3	1.9	7.5	11.0	1.2	W. Va. Circ. 32, p. 3.
Do	3	82.3	3.0	1.9	4.8	7.3	.7	U. S. Dept. Agr., Bu. Chemistry.
Do	1	69.8	2.5	3.1	9.1	14.6	.9	U. S. Dept. Agr., Anim. Hus. Div.[b]
Do	1	77.9	2.2	1.7	6.4	10.0	1.8	Wash. Bul. 158, p. 11.
Average (weighted)	14	77.8	2.4	2.2	6.3	10.4	.9	
Corn	730	70.9	1.4	2.4	6.9	17.5	.9	Farmers' Bulletin 1240 "Feeding Farm Animals."
Corn stover	6	80.7	1.8	1.8	5.6	9.5	.6	
Sorghum	16	77.6	1.7	1.5	7.1	11.0	1.1	

[a] The silage used in these analyses was made from sunflowers harvested when only 5 per cent of the plants were in bloom and therefore without mature seeds.

[b] This analysis was made by Dr. M. J. Blish, of the Montana Agricultural Experiment Station. The sunflowers were grown in 1920 by the Animal Husbandry Division on their sheep ranch near Dubois, Idaho.

The percentage of digestible nutrients in sunflower silage has been determined by the Montana Agricultural Experiment Station and the results are given fully in Bulletin 134 of that station (*10*). The silage used in these experiments was made from sunflowers cut when only 5 per cent of the plants were in bloom. This explains the low percentage of fat (ether extract) shown by the Montana analyses in Table 2. The coefficients of digestibility as determined for this silage were as follows: Crude protein, 59.88; crude fiber, 42.33; nitrogen-free extract, 69.75; and ether extract, 70.63 per cent.

Table 3 shows that the silage made from sunflowers is not equal in digestible nutrients to that made from corn. The amount of digestible crude fiber and nitrogen-free extract combined is higher in corn silage than it is in sunflower silage, but this difference is partly balanced by the higher percentage of digestible fat in the sunflower silage.

TABLE 3.—*Digestible nutrients in 100 pounds of sunflower, corn, and sorghum silage.*

Kind of silage.	Animals used.	Digestible nutrients (pounds).			Nutritive ratio.	Authority.
		Crude protein.	Crude fiber and nitrogen-free extract.	Ether extract.		
Sunflower	3 steers	1.24	10.13	0.37	[a] 8.8	Mont. Bul. 134, p. 8.
Do	do	1.14	10.85	.85	11.2	W. Va. Circ. 32, p. 3.[b]
Do	3 cows	.97	7.72	.91	10.1	Jour. Agr. Res. v. 20, p. 881.
Do	3 sheep	1.10	9.62	.95	10.6	Jour. Agr. Res. v. 20, p. 881.
Do	do	1.00	[c] 8.17	1.45	11.4	Wash. Bul. 158, p. 11.
Do. (average)		1.09	9.30	.91	10.4	
Corn		1.39	17.39	.67	13.5	Farmers' Bulletin 1240, "Feeding Farm Animals."
Corn stover		1.04	10.78	.45	11.8	Farmers' Bulletin 1240, "Feeding Farm Animals."
Sorghum		.87	12.92	.82	16.4	Farmers' Bulletin 1240, "Feeding Farm Animals."

[a] This figure was incorrectly given as 9.8 in Mont. Bul. 134.

[b] The coefficients of digestibility for sunflower silage determined in the Montana experiments were used in computing the digestible nutrients of the silage made in West Virginia to show the difference in results when a silage made from more nearly mature plants is considered. It is recognized that this method is subject to criticism, but the results, it is believed, are approximately correct.

[c] In Washington Bul. 162, p. 15, this figure is given as 8.29.

PALATABILITY.

There are some differences of opinion regarding the palatability of sunflower silage. Most of the evidence from feeding trials conducted in the United States and Canada leads to the conclusion that even though animals may hesitate at first to eat sunflower silage freely, they soon become accustomed to it and, with the possible exception of corn silage, show no preference between it and other kinds of silage. In a number of instances where adverse reports were made as to the palatability of sunflower silage, it is apparent that the crop was not in the right condition when it was put in the silo. At the Huntley (Mont.) and Scottsbluff (Nebr.) experiment farms the sunflowers were not always cut before the seed had reached the hard dough stage, and some of the silage remained hard and woody in the silo.

It is difficult to determine just why the sunflower silage is so uniformly good at Bozeman, Mont., and so often of poor quality or at least low in palatability at Huntley, in the same State. Chemical analyses of sunflower plants grown at Huntley show a lower sugar content than plants grown at Bozeman. This deficiency in sugar may diminish the fermentation processes necessary to produce good silage. A similar difference in the composition of the plants may explain the difficulties which have been encountered at Scottsbluff, Nebr. Holden (*9*, p. 26–28), in his report for the years 1918 and 1919, says that while cows ate the sunflower silage in 1917 very well when it was fed for short periods alternating with corn silage, they did

not eat as much of it as of the corn silage. In 1918, when they were fed on sunflower silage continuously for a considerable period, both dairy cows and beef cattle ate the sunflower silage very well at first, but after 10 days or two weeks they would not eat as much. "It seemed the longer they were fed sunflower silage the less they would clean up. The cows also dropped off in their milk flow."

In 1919 Holden added to the sunflower silage about 10 per cent, by weight, of molasses from the sugar factory. Dairy cows, beef cattle, and fattening lambs ate this silage fairly well, but even with the molasses added they did not relish it as well as they did the corn silage.

At the Wisconsin Agricultural Experiment Station the leaves of the sunflower plants had been killed by rust and drought so that the crop was in poor condition when it was ensiled. T. E. Woodward, in charge of the silage experiments at the experiment farm of the Dairy Division of the United States Department of Agriculture at Beltsville, Md., reports some difficulty in getting dairy cows to eat the sunflower silage, although its quality appeared to be good. Details are lacking regarding the condition of the sunflowers when they were put into the silo at the Michigan station. It is impossible, therefore, to explain its apparent lack of palatability. With the exception of the above-mentioned reports and that of the Pennsylvania experiment station (see p. 24) there has been little complaint about the palatability of sunflower silage.

At the Montana Agricultural Experiment Station cattle, sheep, and hogs ate sunflower silage readily and in sufficient quantities to prove its availability in the rationing of these animals. The West Virginia, Wyoming, and Idaho experiment stations, the University of Saskatchewan, and the Manitoba Agricultural College, in addition to numerous farmers, all report that sunflower silage is relished by dairy cows. It is safe to say, therefore, that silage made from sunflowers which are in good condition and at the right stage of development when cut will in most cases be consumed readily by dairy cows and most other kinds of live stock, with the possible exception of horses.

COLOR, TEXTURE, AND ODOR.

Good sunflower silage is usually a dark olive-brown color, much darker than corn or sorghum silage. In texture it compares favorably with corn silage when the sunflowers have been harvested at the right stage of maturity and stored properly. Most of the complaints regarding the texture of sunflower silage are the result of harvesting the crop too late. When the plants have been allowed to stand until the seeds are in the hard dough stage or even nearer ripe, the stems become woody and do not soften up in the silo.

Sunflower silage has a peculiar odor, which is rather strong, resinous, and somewhat sour, but not offensive. This odor may be one of the reasons why cattle sometimes hesitate to eat the silage when it is first offered to them.

ACIDITY OF THE SILAGE.

A determination of the acidity of sunflower silage was made by the chemical department of the Idaho Agricultural Experiment Station in 1919 (*13*). Three samples were used in the determinations. Samples 1 and 2 were taken from the silo at depths of 2 and 6 feet, respectively. Both of these samples were somewhat spoiled, as indicated by the dark color and disagreeable odor. Sample 3, on the other hand, seemed to have undergone a normal fermentation and had a good color and no disagreable odor. The total acids, considering only sample 3, were found to be 1.37 per cent. The acidity of corn silage made from corn cut when the kernels were in the glazed stage, as determined by the senior author of the above-mentioned article, varied from 1.34 to 2.16 per cent in 1915 and was 1.81 in 1916. For oat-and-pea silage it was 1.66 and for wheat-and-pea silage 1.61 per cent. All these samples were taken from large silos, and the percentages are given on the basis of the composition of the silage as sampled (*12*).

As will be observed from these experiments good sunflower silage is less acid than corn silage or the silage made from a mixture of peas and small grains, and there can be no objection to it on account of its acidity.

RESULTS WITH DAIRY CATTLE.

The Montana, West Virginia, New Mexico, and Washington agricultural experiment stations, the Manitoba Agricultural College, and the University of Saskatchewan all report favorable results in feeding sunflower silage to dairy cows. At variance with their results are the rather unfavorable reports from the Pennsylvania and Michigan agricultural experiment stations and the United States Department of Agriculture field stations at Huntley, Mont., and Scottsbluff, Nebr.

The Montana Agricultural Experiment Station (*4*, p. 18–20) in a series of feeding experiments found that good sunflower silage can be substituted for a large part of the hay in a dairy cow's ration without diminishing the quantity of milk produced. The results indicated that $3\frac{3}{4}$ pounds of the silage equaled 1 pound of choice alsike-clover hay and 2.83 pounds 1 pound of good alfalfa hay.

Sunflower silage was compared with corn silage in feeding experiments with dairy cows at the West Virginia, Pennsylvania,

Michigan, and Washington agricultural experiment stations, at the United States Department of Agriculture field stations at Huntley, Mont., and Scottsbluff, Nebr., and at the Manitoba Agricultural College. The conclusions arrived at by the experimenters differ markedly. It is impossible to determine from available data just why the sunflower silage was palatable in one case and not in another. There are a sufficient number of failures, however, to indicate that more care and judgment are necessary to make good sunflower silage than to make good corn silage.

At the West Virginia (*9*) station the cows fed on a sunflower-silage ration produced per cow a daily average of 27.93 pounds of milk and 1.05 pounds of butter fat, while those fed corn silage produced an average per cow of 29.17 pounds of milk and 1.05 pounds of butter fat daily. In this test the milk produced by the cows fed sunflower silage averaged 3.74 per cent of butter fat and that produced from the corn-silage ration 3.60 per cent. At the Washington station (*20*) the cows ate more silage and less grain during the periods when given corn silage than while they were being fed sunflower silage. During the sunflower-silage periods the cows produced more milk but lost a few pounds in weight. While fed corn silage there was an appreciable gain in weight. The authors of the report conclude that sunflower silage in this test was approximately 92 per cent as valuable as corn silage. At the Manitoba Agricultural College (*1*) a feeding trial was carried on with seven cows from December 19, 1919, to April 1, 1920, the conclusion being that the cows maintained their milk flow and body weight fully as well on the sunflower silage as on the corn-silage ration.

The Pennsylvania station[8] conducted a feeding test with sunflower silage in the winter of 1919–20 and with silage one-half sunflowers and one-half corn in the winter of 1920–21. In each case the standard of comparison was a good quality of corn silage. In the first test the cows while fed sunflower silage averaged 19.3 pounds of milk and 0.92 pound of butter fat per cow daily; while they were fed corn silage the average production per cow was 22.2 pounds of milk and 0.98 pound of butter fat daily. When the cows were changed from corn silage to sunflower silage there was a decrease of 23.5 per cent in the milk and 18.5 per cent in the butter fat produced. When the cows were changed from sunflower silage to corn silage there was an actual increase of 2.3 per cent in the milk produced, notwithstanding an advance of six weeks in the lactation

[8] This preliminary statement of results obtained with sunflower silage by the Pennsylvania station in 1919 and 1920 was supplied by S. I. Bechdel, professor of dairy husbandry at the Pennsylvania State College. A complete report on the sunflower-silage feeding experiments will be published by the Pennsylvania Agricultural Experiment Station.

period. The sunflower silage, which was fed to the limit of the cows' appetites, proved unpalatable. Considerable trouble was experienced in getting the cows to eat enough of it. In this test the milk from the cows while fed sunflower silage averaged 4.75 per cent of butter fat and while on corn silage only 4.39 per cent. In the feeding test with the mixed corn and sunflower silage the cows produced an average of 20.2 pounds of milk and 0.88 pound of butter fat per cow daily, and 21.8 pounds of milk and 0.94 pound of butter fat daily on the corn silage. Again there was a decrease, in this case 14.5 per cent, in the milk produced when the cows were changed from corn silage to the mixed silage containing sunflowers. The corn silage used in the first test contained 30.6 per cent and the sunflower silage 26.6 per cent of air-dry matter. In the second test the corn silage contained 32.9 per cent and the mixed silage 25.8 per cent of air-dry matter.

Prof. Bechdel states his conclusions as follows: "From a study of the complete data of these experiments it is concluded that the use of sunflowers as a silage crop is not advisable on Pennsylvania farms except in a very few localities where corn is not always a sure crop. A mixture of sunflowers and corn, the crops being grown either alone or together, affords no advantage when the poorer quality of silage and the added difficulty of harvesting are taken into consideration."

The Michigan Agricultural College (*11*) reported that the milk production fell off 11.65 per cent when cows were changed from corn silage to sunflower silage. When the cows were taken from a sunflower-silage ration and fed both corn and sunflower silages in equal portions there was an increase of 7.06 per cent in the milk produced. When the change was made from this mixture of silages to pure corn silage there was again a decrease of 5.58 per cent in the milk produced. The results in Michigan seem to indicate that sunflower silage is less efficient than corn silage as a milk-producing feed, but that a combination of the two silages is preferable to either.

Holden (*9*, p. 27) in his report of the work at the Scottsbluff (Nebr.) Experiment Farm for 1918 and 1919 makes the following comment on the value of the different silage crops under test at that station: "From the data available at this experiment farm it is believed that the extra tonnage from silage corn over that from field corn will more than make up for the better quality of the field corn. It is further believed that the ensilage from silage corn is sufficiently higher in quality to offset the greater yield of sunflowers."

Sunflower silage was compared with sweet-sorghum silage as a feed for dairy cows at the New Mexico station (*16*) in the winter

of 1919–20. The author of the report states the results as follows: "The cows did not consume the sunflower silage as readily as the 'cane' silage, and they sometimes left a small quantity of it; but, notwithstanding this fact, the total amount of milk produced on sunflower silage was greater than that produced on 'cane' silage."

In a short feeding test at the University of Saskatchewan (5) sunflower silage was compared with oat silage as a roughage for dairy cows. The former produced slightly more milk, pound for pound, than oat silage.

The results at the University of Saskatchewan are supported by the report of the county agricultural agent of Wallowa County, Oreg., in the Farm Journal of January, 1921, p. 68. In response to a campaign for a wider use of sunflowers for silage, 14 silos were filled with sunflowers in 1919. Field peas and oats had previously been the chief silage crop of that county, and the sunflower silage proved more satisfactory than the pea-and-oat silage.

Another matter of considerable importance to the butter maker has developed in the feeding of sunflower silage at the field station of the United States Department of Agriculture at Ardmore, S. Dak. F. L. Kelso, farm superintendent, claims that considerable difficulty was experienced in manufacturing a satisfactory grade of butter while the sunflower silage was being fed. He says, in correspondence dated June 17, 1921: "It seemed almost impossible to get the butter to harden, although the flavor was fairly satisfactory. An ordinary churning required from an hour to an hour and a quarter while this silage was being fed. Under ordinary circumstances when corn or cane silage is fed it requires approximately 15 minutes to churn. The first churning that was done after discontinuing the feeding of sunflower silage required 22 minutes." This question of the effect on the butter is important and so far has been investigated very little.

Notwithstanding these adverse reports, the conclusion seems warranted that good sunflower silage is worthy of consideration as a constituent in the rations of dairy cows in localities where better silage crops are not available.

FEEDING TESTS WITH BEEF CATTLE.

The Montana Agricultural Experiment Station reports tests in feeding sunflower silage to beef cattle of practically all sizes and ages. Calves were fed, with good results, rations in which one-half or more of the roughage was sunflower silage. It was learned, however, that calves could not be put on a heavy feed of silage too rapidly; when this was done they went "off feed." This difficulty was not encountered with mature cattle. Two-year-old steers were

fed a limited ration of sunflower silage only for 30 days with good results, and mature beef cows thrived when fed sunflower silage in the morning and hay in the evening.

At the Wyoming station it was observed that cattle preferred the sunflower silage to good alfalfa hay or oat-and-pea silage. The silage was found especially valuable in Wyoming as a substitute for pasture during the winter, keeping both dairy cows and beef cattle in a thrifty growing condition.

The New Mexico station also fed sunflower silage to beef cows and young beef stock. It was compared with sweet-sorghum silage for this purpose and found to equal the latter in feeding value. What difference there was in the gains produced favored the sunflower silage (*16*).

At the University of Alberta (*2*) at Edmonton 54 steers were fed for 140 days in a comparison of three kinds of silage. Eighteen head were fed oat silage; 18 head, oat-and-pea silage, and 18 head, sunflower silage. The steers had all the silage and hay they desired in addition to a two-thirds grain and linseed-oil meal ration. The oat and oat-and-pea silages were both first-class. The sunflower silage was not so good, because the crop had to be harvested while it was immature. From 2 to 20 per cent of the plants were in bloom and one field was frosted before harvest. No difficulty was experienced in getting the steers to eat sunflower silage, and there was no trouble from scouring even while they were consuming 73 pounds of silage a day. In this experiment oat silage ranked first in rapidity and economy of gains, sunflower silage second, and oat-and-pea silage third.

There is little doubt from these experiments that sunflower silage can be used with good results in the rations of beef cattle.

USE OF SUNFLOWER SILAGE IN FEEDING SHEEP.

During the winter of 1917–18 the Montana Agricultural Experiment Station conducted an experiment in feeding sunflower silage to breeding ewes. This test was designed to indicate the value of sunflower silage in replacing a part of the alfalfa hay in the ration. The lot fed hay and oats was under test for 77 days, and the lot fed hay, silage, and oats for 74 days. The average gain per ewe during the test period was 13.2 pounds for the hay-fed lot and 12.4 pounds for those in which silage was included in the ration. This slight difference in gain was due for the most part, perhaps, to the slightly greater quantity of oats received by the first lot. The conclusion reached by the experimenters was that in feeding breeding ewes 2½ pounds of sunflower silage is equal to 1 pound of alfalfa hay. No unfavorable results were noted in feeding the sunflower silage either before, during, or after lambing.

The Washington station (*17*, p. 17) found that "a lot of pure-bred lambs made an average daily gain of 0.225 pounds each when fed a daily ration of 1 pound barley, one-half pound cull beans, four-fifths pound of pea straw, and 2½ pounds of sunflower silage." At the same station they were able to maintain breeding ewes in good condition on a daily ration consisting of 2 pounds of alfalfa hay and 3 pounds of sunflower silage.

At the Wyoming station sunflower silage was fed to growing ewe lambs in conjunction with native hay and three-fourths of a pound of a grain mixture daily. In a 42-day feeding period this group of lambs averaged 0.16 pound of gain daily. A similar group fed a like ration in which pea-and-oat silage was substituted for the sunflower silage averaged only 0.145 pound of gain daily.

The United States Sheep Experiment Station near Dubois, Idaho, completed about April 1, 1921, a 55-day feeding test on 1,700 ewes, with the following daily ration for each sheep:

Sunflower ensilage	2 pounds.
Alfalfa hay	1¾ pounds.
No. 2 yellow corn	¼ pound.

The silage was fed from racks 12 feet long, each of these racks accommodating 18 to 20 ewes. The first day half a pound of ensilage for each sheep was distributed. The quantity was gradually increased till the fifth day, when the full 2 pounds, with 1¾ pounds of hay and one-fourth pound of corn per head, were fed. This ration, divided into two feedings, was continued through the test.

In this band of sheep were 1,300 pregnant Rambouillet and cross-bred ewes from 2 to 7 years of age and 400 ewes coming yearlings the following spring, all in good condition at the beginning of winter. They were held on the range until a heavy snow on December 15; then taken to the feed lot and given 4 pounds of alfalfa hay per head daily until January 28. Because this hay was of poor quality the sheep lost condition during the period. From January 29 to March 24 the sheep received the ration mentioned above, containing sunflower ensilage, without hay the last five days, when open range was substituted. The test ended on March 24 when the sunflower ensilage was exhausted. At that time the entire band of sheep was stronger than at the conclusion of the alfalfa-hay feeding period on January 28, and was in good condition for lambing, with strong-stapled well-grown fleeces. Although the sheep had not tasted ensilage before this test, they ate it readily after the second day, preferring ensilage to hay. Only two died during the period, neither death being due to ensilage poisoning. Only three ewes were noticed that had lost their lambs.

Since no water was available at the feed yard the sheep ate snow. Although the sheep wintered well on the feed as described, it is be-

lieved that the ration could be improved by the addition of more sunflower ensilage.

FEEDING SUNFLOWER SILAGE TO HOGS.

The Montana Agricultural Experiment Station (*4*, p. 25–26) has done the principal work in comparing sunflower silage with alfalfa hay in a ration given brood sows. It was found that the sows would eat sunflower silage readily. During a part of the feeding period they consumed 4 pounds per head daily, in addition to a small quantity of skim milk and grain. The silage was fed for two months before farrowing began, throughout the farrowing period, and for a period of about four weeks thereafter, with no unfavorable results. It is acknowledged by the authors of the report on these experiments that but little of the grain in the ration can be replaced by sunflower silage. It did serve an excellent purpose, however, in keeping the sows in splendid condition, being as satisfactory in this respect as alfalfa hay.

SUNFLOWERS AS A SOILING CROP.

Sunflowers have been fed as a soiling crop to dairy cows by a number of experimenters, with good results. The chief disadvantage of this method of feeding is that the plants must be run through a cutter before they are used.

The Montana Agricultural Experiment Station (*4*, p. 22) compared sunflowers to corn as a supplement to pasture. Both crops were cut as needed and run through a silage cutter before being given to dairy cows during the latter part of their grazing season. "The cows ate the green sunflowers readily, kept up their milk flow, and apparently did well on the feed." The conclusion reached was that under the conditions of the experiment as described the sunflowers and corn were of equal feeding value.

A more extensive feeding test was later carried out at the same station, comparing sunflowers and corn as soiling crops. Six cows were fed all the chopped sunflowers they would eat and another six cows all the chopped corn they would eat. Both lots had access to a small pasture and in addition received the same grain ration. At the close of the test the corn was in the roasting-ear stage and the sunflowers were about 40 per cent in bloom. The cows fed sunflowers produced an average of 39.4 pounds of milk and 1.41 pounds of butter fat and those fed corn 38.1 pounds of milk and 1.38 pounds of butter fat per cow daily. During the feeding period of 28 days the cows fed sunflowers lost 7.8 pounds and those fed corn 20.4 pounds of live weight. The slight difference in results favoring sunflowers is no doubt due very largely to the fact that one cow in the corn-fed lot went "off feed" during the period. The results seem to confirm those of the first test and justify the conclusion that sunflowers can be used effectively as a soiling crop for dairy cows.

DISEASES OF SUNFLOWERS.

Rust[9] is the most destructive disease of sunflowers. (Fig. 8.) It is common in southern Russia and has been reported at several points in the United States. Rust was prevalent on these plants at Hays, Kans., in 1920, and has done considerable injury to sunflowers in experiments at both the Michigan and Wisconsin stations. It decreases very decidedly the yield and also results in a poor quality of silage.

The best method of preventing rust injury appears to lie in the development of a rust-resistant variety. Frank Spragg and E. E. Down, in reporting on a variety test of sunflowers at the Michigan

FIG. 8.—Mammoth Russian sunflowers with the lower leaves killed by rust at the Hays Branch Station, Hays, Kans., 1920.

station in 1918 (see Mich. Agr. Quar. Bul., v. 2, no. 3, p. 128–129, 1920), claim for the South American variety Kaeurpher a certain measure of rust resistance. It may be, therefore, that a resistant variety will soon be found.

Some work in breeding a rust-resistant sunflower has been done in Russia. It was found by the investigator, F. A. Sazyperov, that the ornamental sunflower (*Helianthus agyrophyllus*) is resistant to the rust. None of the ordinary commercial varieties are known to be rust resistant. Hybrids were therefore made between one of the commercial varieties and the ornamental sunflower. In the second generation one-fourth of the hybrid plants were found resistant to the rust, although the season was exceptionally favorable to the spread of the disease. Among these resistant plants were

[9] Rust (*Puccinia helianthi* Schw.), the damping-off fungus (*Pythium debaryanum* Hesse), downy mildew (*Plasmopara halstedii* Farl.), powdery mildew (*Erysiphe cichoracearum*), and wilt (*Sclerotinia* sp.), in addition to the parasitic plants *Orobanche cumana* Wall. and *Homeosonia nebulella* Hb. are all said to attack sunflower plants.

individuals which appeared interesting from an agricultural standpoint. Sazyperov concludes, therefore, that it is possible to obtain an agricultural variety resistant to the rust.

INSECTS ATTACKING SUNFLOWERS.

In the warmer and drier parts of the United States insects do considerable damage to sunflowers. At both Amarillo and Chillicothe, Tex., the stalks of the sunflowers were girdled by a larva or white grub which resembled very closely the larva of the June bug. This larva worked at or just below the surface of the soil and usually killed the plant completely or injured it so badly that all growth ceased. Another insect, also at Chillicothe, girdled the stalk just beneath the head, causing the head to drop over.

Besides the above insects several forms of beetles and grasshoppers infest the heads of sunflowers at blooming time and do considerable damage to the seed crop. In 1918 and 1919 grasshoppers very much reduced the yield of sunflowers at Scottsbluff, Nebr., by eating out the terminal bud before the plants headed. Thrips are often abundant on the heads, and aphides, or plant lice, occur in quantity on the leaves. Sunflowers are, however, less injured by chinch bugs than corn, and in some localities where these insects are troublesome sunflowers may prove valuable in replacing corn as a silage crop.

Strangely enough, these insects are all less abundant on sunflowers in the regions of low summer temperature where the plant promises to be most important. Cockerell (*6*) presents a partial list of the insects which are known to visit sunflowers in Colorado, but in most cases he does not indicate the damage caused.

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